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The A. & M. College of Texas

Department of
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PROGRESS REPORT ON RESEARCH CONDUCTED IN GEOLOGICAL OCEANOGRAPHY

MAY 1, 1962 TO APRIL 30, 1963

Office of Naval Research

A. & M. Project 286A

Contract Nonr 2119(04)

Project NR 083-036

Reference 63-10-A

Research Conducted through the
Texas A. & M. Research Foundation
COLLEGE STATION, TEXAS

PROGRESS REPORT ON RESEARCH CONDUCTED IN GEOLOGICAL OCEANOGRAPHY

May 1, 1962 to April 30, 1963

This report summarizes progress during 1962-1963 on research conducted on A. & M. Project 286A (Project Supervisor - Louis S. Kornicker). Project 286A is a subtask of A. & M. Project 286, sponsored by the Office of Naval Research under Contract Nonr 2119(04) (Project Supervisor - Dale F. Leipper).

April 30, 1963

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PROGRESS REPORT ON RESEARCH CONDUCTED IN GEOLOGICAL OCEANOGRAPHY

MAY 1, 1962 TO APRIL 30, 1963

INTRODUCTION

This report summarizes progress made during 1962-1963 on part of the research at Texas A. & M. receiving support from the Office of Naval Research, Contract Nonr 2119(04), Project NR 083-036. This portion of the contract is supervised by Dr. Louis S. Kornicker. Supplementary support contributing to some phases of the program was received from the American Petroleum Institute and the National Science Foundation. Our effort would have been markedly curtailed without the help received by personnel of the Office of Naval Research and this, as well as the research funds made available, is most appreciated.

Our major research effort during the past year was conducted in the Caribbean between Jamaica and Nicaragua and on the Campeche Bank off Yucatan, Mexico. This report summarizes some of the results of work in the Caribbean (Part I) and the Campeche Bank (Part II).

I. CARIBBEAN INVESTIGATIONS

Carbonate sedimentation and environments on the Mosquito Bank, Nicaragua-Honduras (Louis S. Kornicker):

In the northern hemisphere, information is sparse concerning depositional environments on broad shelves where both terrigenous and carbonate sediments are concurrently deposited. Carbonate areas that have already received considerable attention are the Bahama Banks, which are completely

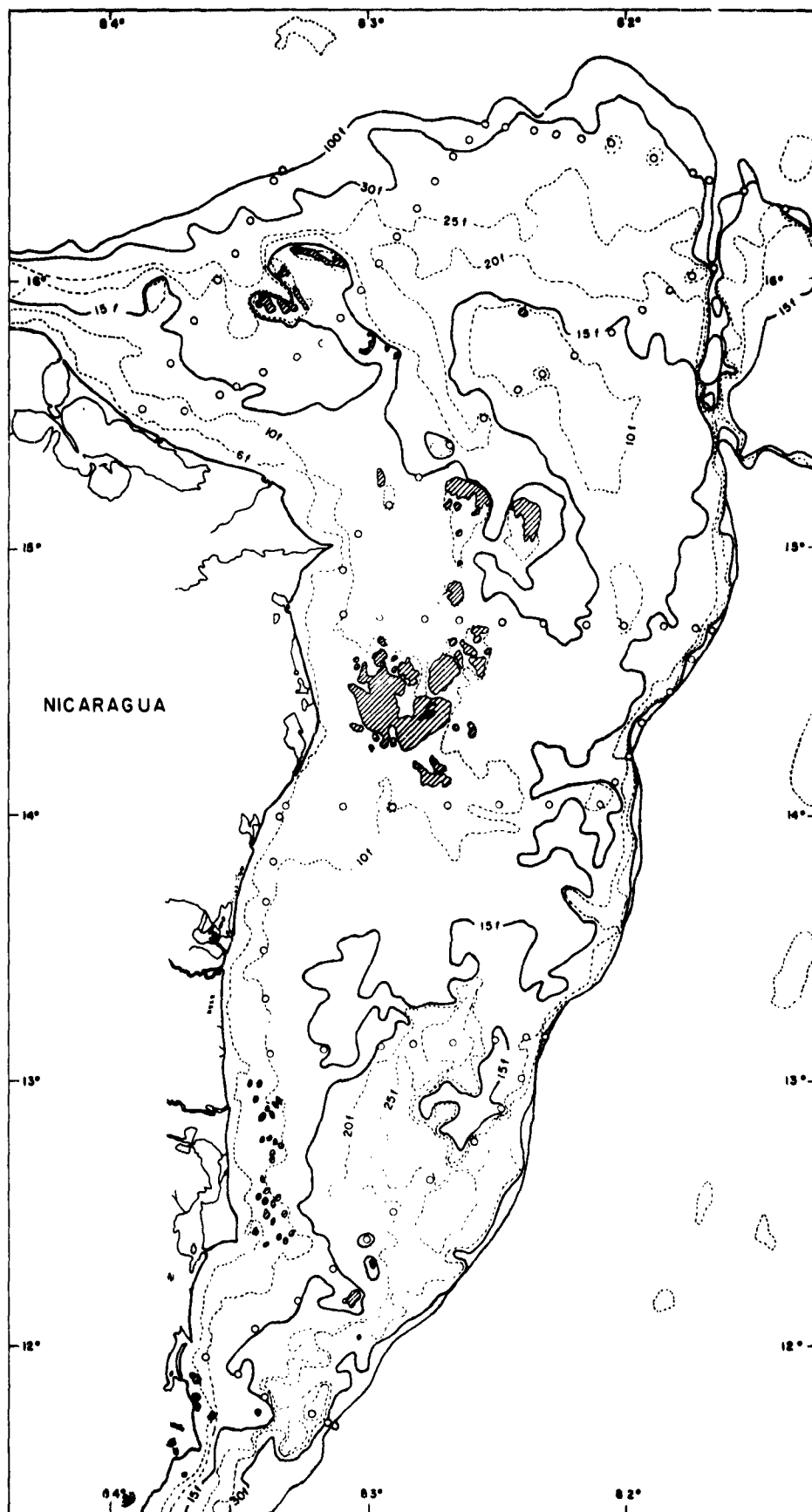


FIG. 1 BATHYMETRY, MOSQUITO BANK

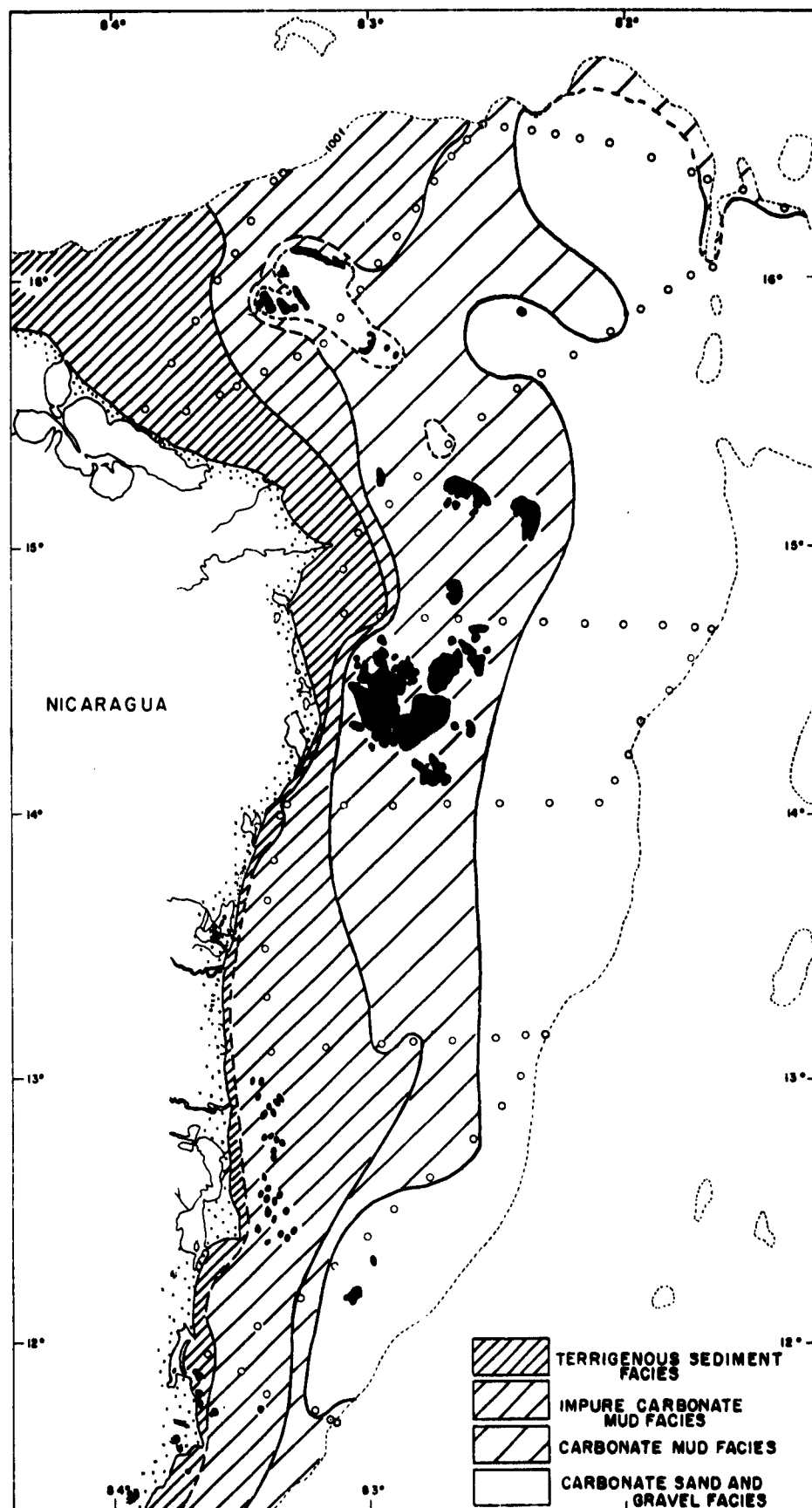


FIG. 2 SEDIMENT FACIES MAP

isolated from a large land mass, and the west Florida and Campeche shelves, which fringe low-lying land masses comprised principally of limestone. The only broad shelf near the American continents containing both living coral reefs and an adjacent high land mass of igneous and volcanic rock is the Mosquito Bank, which extends about 170 miles into the Caribbean Sea off the Nicaragua and Honduras coasts. Some of the results of a reconnaissance study made in this area during August, 1962, on Cruise 62-H-10 are summarized below.

Water depth on the Mosquito Bank seldom exceeds 50 fathoms and numerous coral reefs rise from depths of 15 fathoms or less near the center of the bank (Fig. 1). The shelf gradient is gentle with a slope angle of about 3 feet/mile at the widest part off Cabo Gracias increasing to 4.6 feet/mile to the south off Bluefields.

The most striking feature of the offshore topography is a marked linear orientation of subsurface features such as the NNW-SSE passages between Mosquito and Rosalind Banks and a shallow canyon between Gordo Bank and the mainland coast. The orientation of these features is probably tectonically controlled.

The distribution of sediment facies on the Bank is shown in figure 2. Sands, silts and clay discharged from the rivers of Nicaragua and Honduras are distributed by littoral currents and deposited as a blanket of terrigenous sediment along the coast. Seaward of the terrigenous sediment, impure carbonate mud and carbonate mud with less than 10 per cent terrigenous detritus form an extensive blanket in the central part of the bank. Carbonate sands and gravels cover a large part of the outer shelf.

The distribution of organisms in each sedimentary facies is shown in Table I. Algal nodules are restricted to the carbonate sand and gravel

TABLE I
Distribution of Macroflora and Macrofauna in Coarse Fraction
of Sample^a

	Terrigenous Sediment Facies	Impure Carbonate Mud Facies	Carbonate Mud Facies	Carbonate Sand and Gravel Facies
Number of samples	12	20	25	40
Flora				
Algal nodules	0	0	0	23
Coralline algae	0	0	16	38
Halimeda plates	8	20	48	43
Fauna				
Corals	16	15	48	50
Hermatypic corals	8	5	32	23
Ahermatypic corals	8	15	50	35
Echinoids	16	30	20	23
Barnacles	32	20	20	5
Bryozoa	16	50	72	38
Scaphopoda	64	40	16	5
Worm tubes	8	30	24	48

^aData presented as per cent of samples in each facies containing listed organisms

facies. Coralline algae are restricted to the carbonate mud and carbonate sand and gravel facies. Barnacles and scaphopods are more numerous in the terrigenous and carbonate mud facies; whereas Bryozoa are abundant in the carbonate mud facies.

The results of the study have added significantly to knowledge of this previously largely unknown area, and the work is being continued.

II. CAMPECHE BANK INVESTIGATIONS

Regional aspects of carbonate sedimentation, Campeche Bank (Brian W. Logan):

This investigation has been concerned with (1) delineation of the sedimentary suites on the Campeche Bank, (2) investigations of bathymetry of Campeche Bank with special attention to micro-bathymetry [terraces, shelf mounds and levels of planation] and (3) analysis of the data in terms of environment of deposition and Quaternary history of the region.

The field program for this investigation was concluded with the 73-sediment sample stations occupied on Cruise 62-H-9. Fifty stations on the eastern shelf added greatly to the knowledge of sediment distribution and types in that hitherto sparsely sampled area.

A study of the lithic calcarenite suite of the Campeche Bank (James L. Harding):

Studies of the lithic sediment suite on the Campeche Bank are being undertaken as a Ph.D. dissertation program in the Department of Oceanography and Meteorology.

Approximately 200 thin sections of lithoclasts from Holocene-Recent sediments have been examined since the last annual report. In addition, the collection has been augmented by 50 rock and dune-sand samples from the northern coast of the Yucatan Peninsula and the immediate hinterland. These latter samples were collected on a traverse of the Peninsula during November,

1962. The rock samples from the mainland will be thin-sectioned and comparisons made with lithoclasts in the Holocene-Recent veneer.

The lithoclasts from the Holocene-Recent sediments are composed of seven petrologic types; these are (1) oosparites, (2) biosparites, (3) oomicrites, (4) biomicrites, (5) mudstones, and coral-algal fragments. Distribution patterns of lithoclast-types have been plotted. One outstanding monolithologic pattern is shown by the oosparite lithoclasts which occur dominantly on the outer shelf area between the 300 and 180 feet isobaths. Other less definite trends are shown in the distribution of biosparites and biomicrites. In general, mudstones and coral-algal fragment lithoclasts are limited to close proximity of the reef-supporting inorganic banks.

Staining tests to delineate calcitic and aragonitic cements have been carried out on the available thin sections. General trends in mineralogy of the cements are apparent. Petrographic work has also shown that varying degrees of diagenesis are present in the lithoclasts and this phenomena is being studied further.

A study of the Campeche calcilutite of Wisconsin age (Wayne M. Ahr):

This study is undertaken in order to partially satisfy the requirements for a Master of Science degree in geological oceanography. The objective of the work is to elucidate depositional environment occurring on the western part of Campeche Bank during Wisconsin time.

The Campeche calcilutite is a stratum of Wisconsin age which is penetrated in cores taken from the outer shelf province of the Campeche Bank.

To date 111 cores from this region have been examined under the binocular microscope and 55 of the cores examined penetrated the Campeche calcilutite. These were sampled at intervals for laboratory processing.

Lithologic and stratigraphic descriptions of the cores have been completed. Size analyses have been completed on a few samples and twenty-eight thin sections have been examined under the petrographic microscope. The Campeche calcilutite appears to be an aragonitic lutite with admixed calcareous pellets, planktonic foraminifera and lithoclasts (partially intraclasts).

Several tentative conclusions may be drawn from the work to date; these are:

- 1) The shallowest depth of occurrence of the Campeche calcilutite is 300 feet, and the unit is distributed around the shelf-edge and continental slope from latitude 21°, near the Triangulos reefs to the vicinity of the Alacran reef.
- 2) The stratigraphic contact between the Campeche calcilutite and the overlying Sigsbee blanket (Holocene) is an erosional unconformity from -300 to -450 feet depth, a transitional contact (disconformity?) immediately below the 450 feet isobath, and an almost conformable contact down-slope from the 450 feet isobath.
- 3) Lithofacies distribution suggests that fluctuations of sea level occurred between strandlines at -300 and -450 feet.

A study of the pelletal and oolitic calcarenite suite of the Campeche Bank, emended to Petrology and petrography of the Sigsbee blanket (Joseph D. Williams):

This study is undertaken in order to partially satisfy the requirements for a Master of Science degree in geological oceanography.

The Sigsbee blanket, which is restricted to the outer shelf province of the Yucatan Shelf, is a lithologically distinct portion of the Holocene-Recent sediment mantle. Approximately 130 samples from the Sigsbee blanket have been processed in the laboratory with petrographic examination and size analysis. Silt and clay-size fractions of 25 samples have been mounted for investigation under the high-power petrographic microscope.

Sediments of the Sigsbee blanket contain eight major constituent grain-types; these are (1) planktonic shells and tests, (2) calcareous pellets, (3) ooids, (4) aggregates, (5) lithoclasts, (6) fragments of coralline algae, (7) molluscan fragments, and (8) benthonic foraminifera. Point counts show that the Sigsbee blanket is dominated by a lithology of planktonic lutite with admixed ooids, pellets, lithoclasts and benthonic foraminifera. The most evident lithologic variation within the unit is in relative percentage of planktonic shells and tests, ooids and calcareous pellets. The Sigsbee blanket is divided, on the basis of these environmentally significant constituents, into three major lithofacies which are distributed in broad zones parallel to the depth contours of the outer shelf province. The facies are:

- 1) Planktonic facies occurring on the outer margin of the shelf and on the continental slope.
- 2) Pellet facies occurring in a broad zone bounded by the 600 and 450 feet isobaths.
- 3) Ooid facies occurring in a broad zone between the 180 and 450 feet isobaths with shallow tongue-like extensions between the marginal inorganic banks to the shallowest depths of approximately 168 feet.

The ooids, calcareous pellets and lithoclasts are considered to be products of a shallow transgressive condition which pertained on the outer shelf during late Wisconsin and early Holocene times. The planktonic lutite is the modern depositional type on the outer shelf area and this sediment is being thoroughly admixed with the early lithologies to form an essentially homogenous stratum.

A study of the off-reef clastic suite at the Arcas group (Robert G. Snead):

This study was initiated in May, 1962, and is intended as part of a program for the Master of Science degree in geological oceanography. The aims are threefold:

- 1) To determine the distribution of off-reef bioclastic debris in the Arcas reef group.
- 2) To determine the lithologic characteristics - size analysis and organic skeletal constituents of the off-reef sediment suite.
- 3) To analyze the sedimentary parameters in terms of environment parameters in the reef area.

Field work for this study was carried out at Cayo Arcas over the period June 26 to July 22, 1962 (cruise 62-H-9, R. V. Hidalgo). Three hundred and sixty samples of off-reef sediment were acquired from the reef embayment, reef front and islands. Samples were located on a grid pattern established in reference to a base line laid out on Cayo del Centro, and stations were fixed by triangulation utilizing plane table and alidade and a surveying transit.

To date one hundred and twenty samples of the sediments have been processed in the laboratory with binocular examination, size analysis and impregnation for thin section production.

A study of the zoogeography of the molluscan faunas of the Campeche Bank
Mrs. W. Rice and Louis S. Kornicker:

Studies of the molluscan faunas of the Campeche Bank were begun in September, 1961. To date molluscs have been identified from the coarse fraction of 22 grab samples obtained in depths of 15 to 120 fathoms. The molluscan faunas of the shelf are distinct from the reef fauna since, of the 156 species from the shelf, only 11 are included among the 125 species identified from Alacran reef by Rice and Kornicker (1962).

Preliminary studies of species distribution relative to the present water depth suggests that shell accumulations in water shallower than about 45 fathoms consists of a mixture of remains of mollusks living at the sample depths and mollusks now restricted to shallower depths. The latter forms are probably relicts of a lower sea level present during the post-Wisconsin transgression. The presence of relict mollusk shells in bank sediments has been demonstrated by carbon 14 dating.

It is envisioned that as sea level rose mollusk species moved landward in sublinear bands more or less parallel to the depth contours with the geographic position of each band controlled by water depth. As the leading margin of the band moved landward the rear margin followed in its wake leaving a trail of shells now mixed with those of species of ensuing bands.

The community structure of mixed and admixed assemblages is being studied with the objective of devising methods of distinguishing mixed and unmixed assemblages in fossiliferous rocks.

Detailed mapping of the reef biota, Arcas reef group (Louis S. Kornicker):

The main purpose of this research was to lay a foundation for repetitive mapping of critical sections of the Arcas reef in connection with an intended dynamic processes study. The essential point at this stage was to develop a satisfactory technique for handling the ecological system on the reef face. Approximately three weeks were spent on Cayo Arcas during July, 1962, and during this time the writer, assisted by Mr. Max Pitcher, developed a technique for making a photo mosaic of the reef surface. The method is described briefly below:

- 1) A spool of B.T. cable was suspended across the diving well of the raft, described elsewhere in this report, so that the cable could easily be fed to a diver underwater.
- 2) The loose end of the cable was then fastened to the instrument pole installed as part of the reef instrumentation program (this report).
- 3) The raft then proceeded along the desired traverse while a diver in the water fed the cable between and around coral growths. At the end of the traverse, cable was wrapped around a small patch reef.
- 4) Then, a 100 foot tape was laid alongside the cable and vertical close-spaced photography was taken along the tape using a 35 mm underwater camera equipped with a wide-angle lens. Approximately 200 pictures were taken along the traverse, a distance of about 400 feet.

5) Pictures obtained in this manner may be used to make a mosaic of the bottom which can be used as a base map. The preliminary study showed that the technique has promise.

Color film was found to be superior to black and white in that living coral could be distinguished from reef rock more easily. The method could be improved by use of a flash attachment in the area to be photographed to eliminate shadows. Numbers on the tape could not be distinguished in water deeper than six feet, so that a wider tape with large numbers is recommended. The operation is best performed under calm sea conditions, and a support to maintain the camera in a horizontal position would be helpful. A system was devised for determining the relative areal coverage of various species using a point count method of photographs.

Wave refraction at the Arcas reef group, Campeche Bank (Donald E. Walsh):

This program, which has been completed, was undertaken to provide a theoretical basis for environmental studies at the Arcas reef group. Appraisal of weather data (provided by the National Records Section of the Weather Bureau) for the Campeche region indicated that a northeast direction of wave approach is the dominant prevailing regime at the Arcas reef. Computations of wave patterns, wave energy and littoral drift, based on an assumed northeast wave train of six second period, have been completed.

Reef instrumentation study (Jack O. Hill):

Preliminary work for a study of dynamic physical and geological processes at the Arcas reef group was carried out during part of cruise 62-H-9.

The objectives were (1) to perfect techniques for installing instrument-bearing structures on the reef with a view to future construction, and (2) to test the strength of a structure under actual field conditions before placing expensive instruments.

A ten feet long, 3 inch schedule 80 pipe was selected as the vertical support member. The lower four feet of the pipe had 1/2 inch holes drilled through it. Rods were inserted in these holes to form a crossed network of reinforcing members. This lower end was then cemented into a 3 feet deep by 3 feet diameter hole in the reef face. Drilling the hole in the reef, placement of the concrete, and positioning the post vertically was done by Scuba divers working from a 16 feet by 16 feet raft-type barge designed and constructed for this purpose. The exact position of the post was located on maps of the reef prepared by Mr. Robert Snead.

The next step in reef instrumentation would be periodic inspections of the structure with checks for survival, fouling, and influence the post had on the surrounding environment.

Beach studies at Cayo Arcas (Louis S. Kornicker):

Concurrently with the development of a technique to map the reef face at Cayo Arcas, several studies of a reconnaissance nature were made to define problems concerning geological processes that might be amenable to analysis by repetitive measurements during the intended dynamic processes studies.

To enable precise relocation of study areas, concrete blocks were installed in places on the island of Cayo del Centro and marked on a reference

map using an alidade. Secondary points were marked with wooden pegs. Temporal changes in beach structures and sediments are relatively rapid and therefore processes involved in beach formation are usually amenable to study by repetitive measurements.

The main island of Cayo Arcas has a westward pointing spit at each end during the summer which is removed during the winter months. The positions of these in July were accurately mapped as a starting point for future studies on spit formation and distribution. The slope of the north-facing beach of the spit at the southern end of the island ranges from 8 degrees at the water's edge to 22 degrees on the upper part of the beach. A lip 4 to 20 inches high that moves in and out with the tide in water 3 to 5 feet deep had a slope angle ranging from 7 to 20 degrees. Another lip, 3 to 8 feet from the previous lip and located below low tide level in water 23 to 26 inches deep, had slope angles ranging from 26 to 29 degrees.

Removal of sand by wind from the flat top of the spit, which was about four feet above low tide, was measured over an 11 day period by using marks on small sticks inserted into the sand as references. In two areas about 12 feet apart the sand surface was lowered by $5/8$ inch by wind removal of sand particles during the 11 day period of observation. During the same period small waves lapping onto the southern rim moved the top of the slope 12 inches inland. Similar structures made in other beach areas on the main island indicate that geological processes are sufficiently active here to make studies based on repetitive measurements of beach parameters along with measurements of environmental factors that affect them worthwhile.

Reconnaissance study of the moat, Cayo del Centro (Louis S. Kornicker):

One of the projects during the summer field season at Cayo Arcas was to investigate the environment in a narrow moat developed between the island and outer rubble rampart on the reef flat preliminary to proposed installation of instruments to study sediment transportation across the reef flat and in the moat. Surface and bottom temperatures increased from 74.8°F. in six inches of water at the southern end to 88.4°F. at the northern end where water depth is about four feet. The water in the channel travels almost continuously northward with a velocity that increased from five feet/minute at the southern end to 100 feet/minute at the northern end. The increase in velocity and increase in temperature in the northern part of the moat is caused by an increased volume of water coming into the moat over the reef top. The water temperature in front of the reef was about 83.7 degrees. The channel bottom at its southern end is floored with coral shingle sand. About 100 feet to the north shingle is replaced by mud and sand which continues for another 250 feet. Sand floors the rest of the channel except near the northern end where living corals extend over a considerable area and partly fill the moat. Corals in the moat may be divided into a massive coral zone where current velocities were below 100 feet/minute and an Acropora palmata zone where current velocities of 100 feet/minute were attained during the time of observation.

Physical oceanography of the Campeche Bank (Louis S. Kornicker):

A start has been made in bringing together physical oceanographic data concerning the temperature, salinity, chemical properties and current

direction and velocity of water passing over the Campeche Bank. Data from oceanographic cruises made since 1919 to the Campeche Bank by other institutions have been obtained from the National Oceanographic Data Center, Washington, D. C. This is being combined with that collected at Texas A and M. Currently bottom and surface temperatures on the Bank are being plotted on base maps. This work is being done in cooperation with Mr. John Cochrane, physical oceanographer at Texas A and M. Tentative plans have been discussed for making a synoptic study of water on the bank during winter and a summer month using several vessels.

III. PUBLICATIONS AND REPORTS

Publications and reports by staff with O.N.R., A.P.I., or college support since May 1, 1962 are as follows:

1. Publications

Kornicker, Louis S.

1962, Shallow-water geology and environments of Alacran Reef Complex, Campeche Bank, Mexico: Am. Assoc. Petroleum Geologists Bull., v. 46, no. 5, p. 640-673, May (with Donald W. Boyd)

1962, Evolutionary trends among mollusk fecal pellets: Jour. Paleontology, v. 36, no. 4, p. 829-834, July

1962, Island transport of marine shells by birds on Perez Island Alacran Reef, Campeche Bank, Mexico: Jour. Geology, v. 70, no. 5, p. 616-618, Sept. (with Thomas Wright)

1962, Floating corals: a possible source of erroneous distribution data: Limn. and Ocn., v. 7, no. 4, p. 447-452, Oct. (with Donald F. Squires)

1962, Sarsiella (Ostracoda) in Texas bays and lagoons: Crustaceana, v. 4, pt. I, p. 57-74 (with Charles D. Wise)

1962, Mollusks of Alacran Reef, Campeche Bank, Mexico: Inst. of Mar. Science, Univ. of Texas, v. 8, p. 366-403 (with Winnie Rice)

1962, Sedimentation from a hydraulic dredge in a bay: Inst. of Mar. Science, Univ. of Texas, v. 8, p. 212-215 (with Thomas R. Hellier, Jr.)

1963, Ecology and classification of Bahamian Cytherellidae (Ostracoda): Micropaleontology, v. 9, no. 1, p. 61-70, January

1963, The Bahama Banks: a "living" fossil-environment: Jour. Geol. Edu., p. 17-25, March

2. Reports

Kornicker, Louis S.

1962, Summary report--Cruise 62-H-10, July 17-August 13, 1962, Galveston, Texas--Kingston, Jamaica--Nicaragua-Honduras Shelf: Unpub. tech. report, Dept. of Ocean. and Meteor., A. and M. College of Texas, Reference 62-15-T, 41 pages

1962, The resistance of recent marine carbonate sediments to solution: Unpub. tech. report, Dept. of Ocean. and Meteor., A. and M. College of Texas, Reference 62-18-T, 70 pages (with John F. Jansen, Yasushi Kitano, Donald W. Hood)

Logan, Brian W.

1962, Classification and environmental significance of stromatolites: Unpub. tech. report, Dept. of Ocean. and Meteor., A. and M. College of Texas, Reference 62-10-T, 23 pages, 6 plates

1962, Summary report--Cruise 62-H-9, June 27-July 12, 1962, Galveston, Texas--Campeche Bank: Unpub. tech. report, Dept. of Ocean. and Meteor., A. and M. College of Texas, Reference 62-17-T, 15 pages

3. Abstracts

Harding, James L.

1963, Structure of portions of the Northern Continental Shelf, Gulf of Mexico, as determined by seismic refraction measurements: Am. Assoc. Petroleum Geologists Bull., v. 47, no. 2, p. 349, Feb. (with John Antoine)

Kornicker, Louis S.

1962, Recent algal bioherms near Cozumel Island, Mexico: National Meeting, Geol. Soc. of Amer., Houston, Nov. (with Donald W. Boyd and Richard Rezak)

1962, Hydrography and sedimentology in the vicinity of Bimini, Great Bahama Bank: Texas Jour. of Sci., v. 14, no. 4, p. 415, Dec.

4. Nontechnical Publications

Kornicker, Louis S.

1962, Students of the sea: Texas Game and Fish, p. 30-31, August

1962, How many oceanographers in the United States: GeoTimes, v. 7, no. 4, Nov.-Dec.

1963, Students of oceanography: Waterfront News, v. 1, no. 1, p. 13, March

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